Modeling 3D Coastal Circulation in Boundary-fitted Coordinates: The GCOM Project

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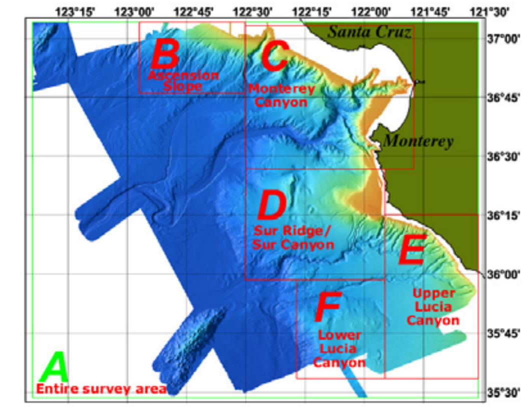
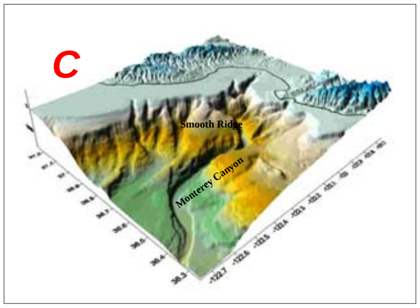
Study Site and Hydrographic Characteristics



http://www.mbari.org/data/mapping/monterey/images/monterey_canyon_1000x957.jpg

Monterey Bay (MB) is the largest bay of the West Coast of the United States. It is characterized by a complex coastline and regions of steep bathymetry.



Local upwelling events and strong land/sea breeze influence circulation patterns in this area.

During Spring and Summer near-surface water offshore of the Monterey Bay flows mostly southward due to local equatorward wind stress and the influence of the California Current. There also exist two narrow poleward flowing boundary currents around the Monterey Bay area: The Inshore Countercurrent, IC, also called the Davidson Current, and the California Undercurrent (CU) [1].

Topographical characteristics as well as atmospheric and oceanographic conditions and processes make the MB region ideal to exploit the capabilities of a 3*D* curvilinear ocean model such as the General Curvilinear Ocean Model, GCOM [2, 3].

GCOM is based on the non-hydrostatic, non-linear primitive equations for momentum and density in the *f*-plane. It is capable to handle the complex combination of rotation and abrupt bathymetry. It has been used successfully to model flow circulation and density evolution in a variety of places with different coastline and shape basins such as The Gulf of Mexico, The Gulf of California [4] and The Bahia de Todos Santos [5] in México. Also it has been applied to the Valencia Lake [6] and Catatumbo region in Venezuela.

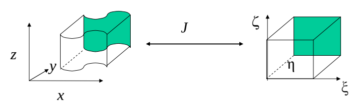
GCOM 3*D* Curvilinear Model for the Monterey Bay Area

Adapted (orthogonal or non-orthogonal) Curvilinear Grids

Curvilinear grids are capable to adapt coastline and bottom surface. The curvilinear transformation is given by;

$$x = x(\xi, \eta, \zeta),\ y = y(\xi, \eta, \zeta),\ z = z(\xi, \eta, \zeta)$$

$$\xi = \xi(x, y, z),\ \eta = \eta(x, y, z),\ \zeta = \zeta(x, y, z)$$



Physical Domain — Computational Domain

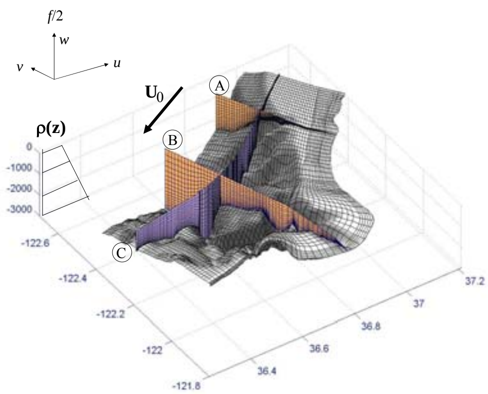
Model Characteristics

- **Coastline and bathymetry adapted non-orthogonal curvilinear grid**
- **Variable resolution ranging from 250m to 700m in the horizontal.**
- ***z*-coordinate 20 layers with clustering of grid points near the bottom depth.**

<u>Initial and Boundary Conditions</u>:

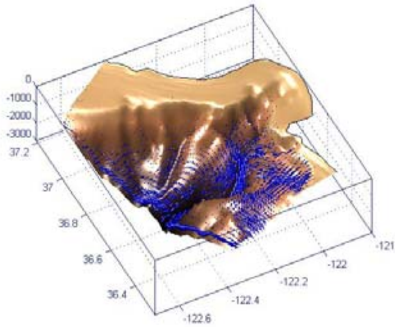
- **Linear Stratification**
- **Current at the outer boundary as shown in Figure.**
- **At the downstream boundary, flow is allowed to leave the domain.**
- **Non-slip at solid boundaries.**

For this exercise we used dimensionless numbers *Re* = 50, *F* = 20 and *Ro* = 0.95.

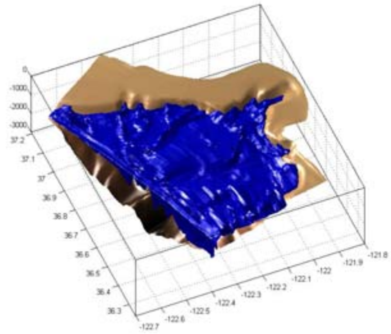


Preliminary Results

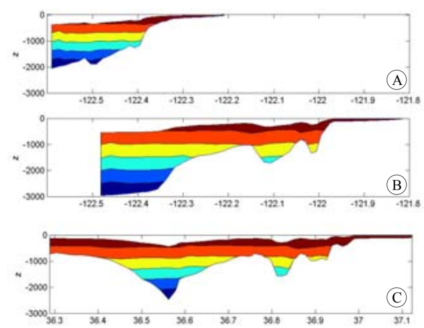
3*D* bottom velocity vectors



Density surface at *z* = 350 m



Density profiles *t* = 48



Conclusion

We have used the General Curvilinear Ocean Model (GCOM) to study 3*D* circulation at the Monterey Bay area for flow conditions *Re* = 50, *F* = 20 and *Ro* = 0.95. The simulations show bottom down-canyon currents at Monterey Canyon, as well as in secondary, Cabrillo, Año Nuevo and Ascensión canyons (left panel). That currents could be important in sediment transport processes in such zones by modeling the channel floor (see for example ref [7]). Density surface (middle panel) and isopycnals undulation (right panel) could indicate internal wave activity in the region. This model results demonstrate the ability of GCOM to simulate detailed three-dimensional flow in 3*D* realistic bathymetry by using curvilinear grids.

In the near future it is planned to couple GCOM to larger models and include atmospheric forcing to increase the model predictive skills.

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